Technical Assistance

Case Study

FEMP
FEDERAL ENERGY MANAGEMENT PROGRAM

The PJKK Hybrid Hot Water System

An innovative water-heating system combines solar energy with waste-heat recovery at a Honolulu Federal building

Hawaii's sunny, tropical climate powers more than just the state's tourist industry. At the 1,080,300-square-foot (100,363-square-meter) Prince Jonah Kuhio Kalanianaole (PJKK) Federal Building in Honolulu, sunshine will be the primary source of energy for the facility's new water-heating system.

The combination of Hawaii's excellent solar resource and the high price of natural gas inspired PJKK facilities personnel to seek alternatives for meeting their energy needs. The facilities group turned to the Federal Energy Management Program (FEMP) for help in determining where cost-effective energy-saving measures could best be applied. FEMP specialists conducted an energy audit at the facility and identified water heating as an area in which substantial quantities of energy could be saved.

The PJKK building is managed by the General Services Administration (GSA) and is occupied by a number of Federal agencies. The building uses about 2800 gallons (10,600 liters) of hot water daily in its cafeteria, showers, and lavatories. The cafeteria, which serves 500 breakfasts and 900 lunches on any given day, is the building's largest single hot water user. The building's existing boilers are fired by natural gas, which at $1.22 per therm is about three times more expensive in Hawaii than it is on the mainland.

With FEMP leadership, an engineering team from the National Renewable Energy Laboratory and Sandia National Laboratories monitored hot water use patterns and conceived of an innovative water-heating system that takes advantage of Hawaii's uniform solar resource and waste heat from the building's chiller. This "hybrid" system will reduce natural gas consumption by 83%. The new system was scheduled to be operational in the fall of 1996.

David Baker, PJKK's property manager, believes the project is valuable from both an economic and an environmental standpoint. "Given the value of energy conservation and the emphasis within the GSA to cut costs, the hybrid water-heating system is an ideal way to save taxpayer dollars."

FEMP technical assistance saved energy and reduced costs at the PJKK Federal Building in Honolulu, Hawaii.

Heating water with waste heat and sunlight

The GSA was eager to reduce energy use, but it was interested in doing so at a minimum cost. The engineers designing the new hot water system focused on keeping the life-cycle costs as low as possible, which led to the innovative hybrid design. The contractor designed the system to the specifications set by FEMP's team of energy specialists.

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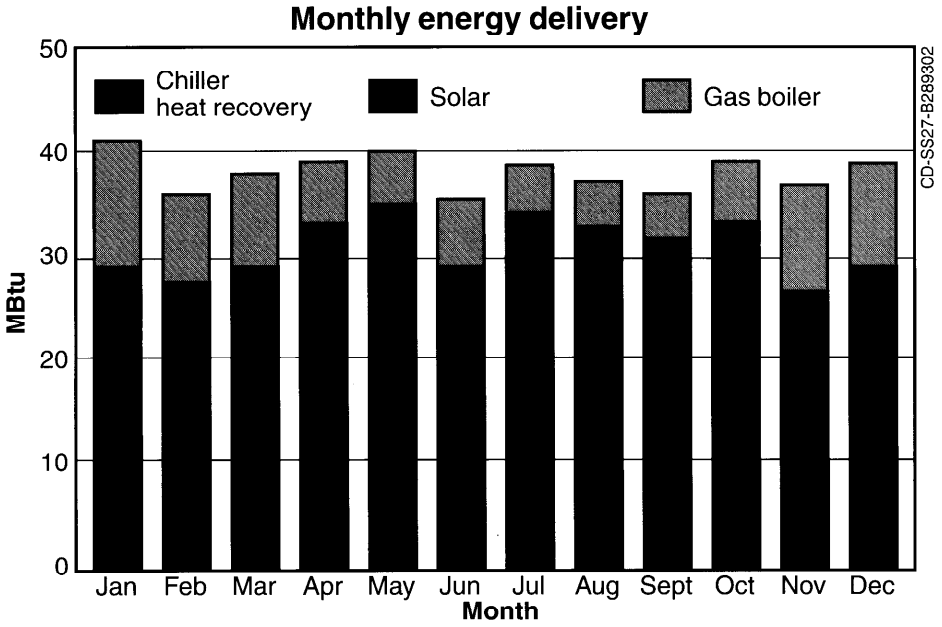

The optimized heating system consists of (1) a frame and plate heat exchanger that recovers waste heat from the building's chiller and (2) a solar water-heating system consisting of 768 square feet (71 square meters) of flat-plate solar collectors manufactured by American Energy Technologies, Inc. Heated water from both systems is stored in a common 1300-gallon (4920-liter) storage tank.

To recover heat from the chiller, water from the main supply line enters the chiller heat exchanger at 70°F (21°C) and is heated to 93°F (34°C). The heated water exits the heat exchanger and is piped to the storage tank.

The solar array supplies the energy that further heats the water to its useable temperature of 140°F (60°C). A pump circulates the water from the tank through the solar collectors. The water circulates continuously through the solar array until the temperature reaches 180°F (82°C), at which point the system controller will turn off the solar loop pump. When the water in the tank exceeds 140°F (60°C), a tempering valve downstream of the tank will automatically mix in the needed quantity of cold water to ensure water is delivered to the point of use at a safe temperature.

If the sun goes down or is blocked by clouds, and—as a result—the temperature difference between the solar collector outlet flow and the water at the bottom of the tank drops below 4°F (-16°C), the controller turns off the solar loop pump. If the temperature of the water being delivered to the building falls below 140°F (60°C), a gas boiler switches on and brings the water up to set the temperature.

Performance and cost

The hybrid water-heating system at the PJKK building will supply about 83% of the annual Btu load for heating water. The chiller heat exchanger will recover 117 MBtu, which equals 28% of the load, and the solar collection system will deliver 234 MBtu, or 55% of the load. The natural-gas-fired backup water heater will provide the remaining 17%. The graph shows the energy each of these systems will deliver each month. The hybrid system will supply about 75% of the building's hot water in winter and about 90% during the summer.

An analysis of the hybrid system's cost and performance shows the project to be cost effective, with a simple payback period of 9 years. The estimated cost of the project is $58,389. The present value of the life-cycle cost of the hybrid water-heating system, including maintenance and fuel, is $83,800. The levelized cost of the solar energy is $7.20 per MBtu, and the calculated adjusted internal rate of return is 6.65%.

Other benefits

In addition to saving energy and money, the hybrid water-heating system increases the facility's hot water capacity. Because the water is usually stored above 140°F (60°C), it is mixed with cold water to bring it down to a useable temperature, effectively increasing the total volume of hot water the system can deliver.

The GSA also benefited from good timing. The building's existing boilers had reached the end of their useful lives and needed to be replaced soon. The new hybrid system averted the expense of new boilers and their associated fuel costs.

Property Manager Dave Baker says FEMP's assistance was the key to the project's success: "We have really profited from FEMP's involvement. In addition to bringing technical expertise, the FEMP staff was helpful at every stage, and they were 100% dedicated to making this project succeed."

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